Consideration for Improvement of Dementia that uses Communications

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***Abstract*-We measured plethysmograms and calculated Largest Lyapunov Exponent (LLE) with nonlinear analysis method. We found the value of LLE had significant relation to dementia degree and the communication skill of the ADL index for the measurement of 144 elderly people. We made a mathematical model to discuss the obtained experimental results by studying simulated what kind of information was able to extract from the plethysmograms data. Furthermore, we performed the measurement when we blocked the central nerve by general anesthesia to inspect the mathematical model. As a result, the data of the pulse wave elucidated that we included information of nucleus of the brain origin. In other words we got the conclusive evidence of having meaningful relation to dementia and LLE and a communication skill. We had an old man communicate in friendly care manager to an elderly people from these facts and measured the pulse wave at the same time. We calculated a sympathetic nerve, the value of the parasympathetic (LF/HF, HF) at the same time. As a result, the person whom LLE activated by communication had a low HF, and the person who was not activated understood that HF was in a high state. In other words an effect of the communication was accepted when an elderly people awoke. By this study, the communication was able to prove that we helped the mental activation of the elderly people scientifically.**

Keywords-plethysmograms, Largsrt Lyapunov Exponent, nonlinear analysis, ADL index, anesthesia, HRV

I. INTRODUCTION

Biogenic information is all complex systems. For example, heart beat, blood pressure, blood flow, etc. The dynamic rhythm of the biogenic is neither a constant rhythm like the metronome nor a random rhythm. Most of the natural world has chaos in the dynamic rhythm.

The change in the blood stream is examined by using infrared rays for the capillary of the finger. Fig.1 shows the method of measurement of finger plethysmograms, with sampling rate of 200Hz and 12bits resolutions.

Given a time series x(i), with i=1,..., N, the phase space is reconstructed by using the method of delays. Assuming that we create a d-dimensional phase space using a τ constant delay lag, the vectors in the space are formed by d-tuples from the time series and are given by

$$\mathbf{x}(i) = (x(i), ..., x(i-(d-1)\tau)) = \{x_k(i)\} \quad (1)$$

Where $x_k(i) = x(i-(k-1)\tau)$, with k=1,..., d. In order to correctly reconstruct the phase space, the parameters of delay lag τ and embedding dimension d should be chosen optimally. On the reconstructed phase space, one of the important complexity measures is the LLE. The LLE characterize how a set of orthonormal, infinite small distances evolve under the dynamics. For a chaotic system, there is at least one positive Lyapunov exponent, let $\lambda_1 > 0$ be the largest exponent. The defining property of chaos is sensitive dependence on initial conditions, in the following sense. Given an initial infinite small distance $\Delta x(0)$, its evolution obeys

$$\Delta x(t) = \Delta x(0)e^{\lambda_1 t} \quad (2)$$

For an M-dimensional dynamical system, there are M Lyapunov exponents. We estimated only λ_1 using algorithm of Sano and Sawada (1985). Paraneters: d-dimensional phase space d= 4. τ : time delay 50 ms.

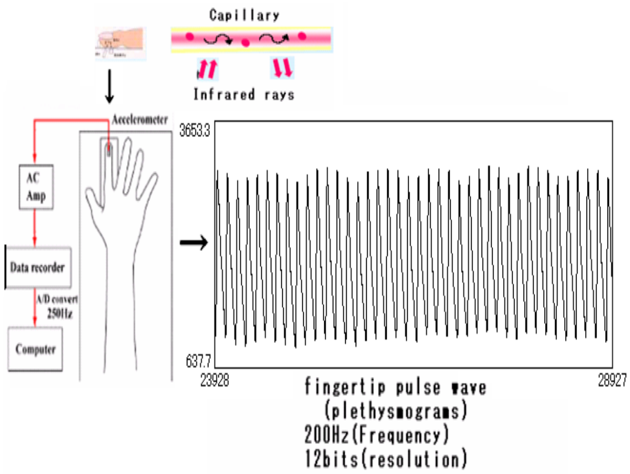

Figure 1. Method of experiment using finger wave pulse records.

II. MATHEMATICAL MODEL

To understand emergence of changes of chaos in the finger plethysmograms in the experiments, a mathematical model is proposed. Fig.5 shows a schematic description of the model used in this paper. The model consists of a feedback loop and physiological factors (Miao et al 2006). The pressure receptors are the sensors of the system, which senses and transmits neural afferents from pressure to cardio-vascular centre. Neural efferents are created and then sent to effectors. There are influences both from respiratory centers and from higher cerebral region.

It notes that pulsations in blood volume of ear were able to be represented as a response function to pulsations in radial artery, and whence a proportional relation between the finger plethysmogram and artery blood pressure can be approximately assumed. Thus, for sake of simplifying unimportant details, our model concentrated on dynamics of blood pressure in a well approximation to approaching finger plethysmograms without loss of generality.

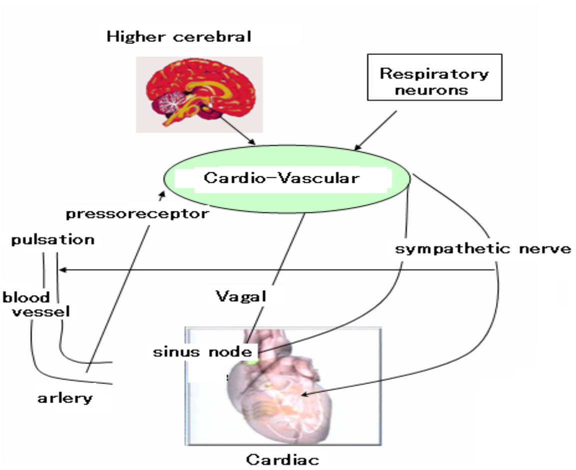

Figure 2. Schematic representation of mode

III. VERIFICATION FROM ANESTHETIZING EXPERIMENT

We experimented on anesthetizing to verify the mathematical principle model. The patient participated the experiment was a male aged 71. He was made a deeply anesthesia in order for a surgery of cancer treatment.

The surgery taken place at Rakuwakai Otowa Hospital, Kyoto, December 12, 2008. The participant gave informed consent to all experimental procedures.

The subject slept comfortably in a hospital bed in a relaxed manner. The hand was softly put on the side of his body, held in a relaxed semi-open position, with the palm turned downward. A photoelectric sensor of the plethysmography was placed on the distal phalanx of second finger. Finger plethysmogram was recorded continuously for all processes including before, during and after the surgery, by an instrument (BACS2000; CCI). The signals were digitized with a 200Hz sampling rate with resolution 12 bits, and transferred via an A/D converter to a PC for data processing.

The passage of time to have used anesthetizing by the operation is shown in table 1. The pulse wave was continuously measured for a long time from 9:10 AM to 14:25 PM. The situation that is changed from anesthetizing by the injection into anesthetizing suction and done is understood. Figure 8 occupies the LLE under the operation. The part of the noise to the pulse wave caused by the radio-knife omitted and calculated 23 files pulse waves on the way. The LLE occupied by blocking information on the center system by anesthetizing and a small value was occupied from 0 to 1 though the value of able-bodied person's exponent changed by using the same parameter between from 3 to 5. Moreover, when anesthetizing wakes up, t21 and t23 are interesting and it is also interesting that uptrend is seen because of the voice of the patient food or disregarding.

Chaotic dynamics in finger plethysmogram system was studied in relation to anesthesia processes. The LLE of the plethysmograms was found to be significant and can be used to characterize the changed in mental/physical status for the experimental processes. There were lower values of Lyapunov exponents, indicating a blocked or depressed effect of anesthesia on central neural system. We found there a further smaller values estimated during the laparotomy and change O2 to 50%, showing the effect of comedown on mental status. Whereas there was a LLE in recovery consciousness from anesthesia, even higher than the period of time before preparation of the surgery. To understand how the chaos arises and to explain the changes in the LLE in finger plethysmograms in experiments, a mathematical model consisting of baroreflex feedback and autonomous interactions was proposed and studied numerically. By using of the model, the decrease of the LLE in plethysmograms was explained in relation to the decreased chaoticity, and hence the depression or blocked central nervous system in higher cerebral region. Highly arising values of Lyapunov exponent was theoretically explained as caused from excitations in activities underlying central nervous system.

9:10	Start	
9:12	Oxygen inhalation	
9:16	Beginning anesthesia	
9:17	Deportation	
9:21	Head Down	
9:22	Inserting Catheter	
9:39	Head Up	t01
9:43	Change O2 to 50%	
		t02
		t03
9:54	Hand move	
10:09	Catecholamine infusion	t04
10:16	Bbeginning surgery	
10:17	Pain stimulation	
		t05
10:23	Pneumoperitoneum	t06
10:30	Arrhythmia	
10:40	Change body position	t07
11:35	Change O2 to 75%	
11:51	Change body position to horizontal	
11:52	Laparotomy	
		t08
12:05	Change O2 to 50%	t09
		t10
		t11
		t12
		t13
		t14
		t15
		t16
		t17
		t18
13:36	Start working closing ventral	t19
13:55	Finished	t20
13:56	Change O2 to 100%	
14:00	Head Down	
	Bed in horizontal	
14:03	Hand move	
14:11	Change O2 to 100% & Atropine sulfate injection	
14:20	Recovery consciousness	t21
14:23	Remove the respirator	
		t22

Table I: Processes before, during and after the surgery.

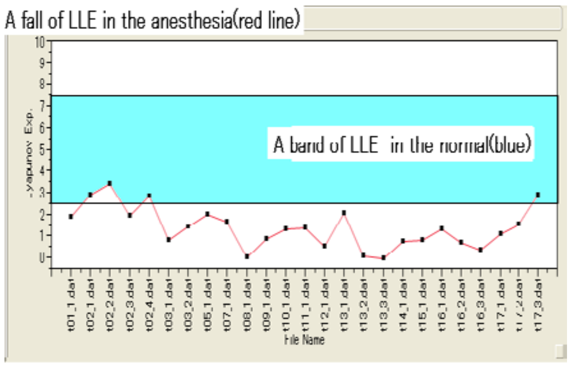

Figure 3. LLE in plethysmograms was explained in relation to the decreased chaoticity, and hence the depression or blocked central nervous system in higher cerebral region.

IV. STUDIES OF AGED SUBJECTS WITH DIFFERENT COMMUNICATION SKILLS

Subjects: Data were obtained from 179 subjects (40 male, 139 female) at three nursing homes for the aged in Shiga prefecture, Japan.

Indices: We obtained data for the ADL index of communication skills (three-graded evaluation), composed of seven items and estimated by a care manager. We examined the relation between the data and the LLE calculated from the fingertip pulse waves.

Results Five grades indicating the severity of dementia judged by a doctor. We obtained data seven items of ADL index of communication skills (three graded evaluation), composed of seven items and estimated by a care manager. We examined the relation between the data and the LLE calculated from the fingertip pulse waves.

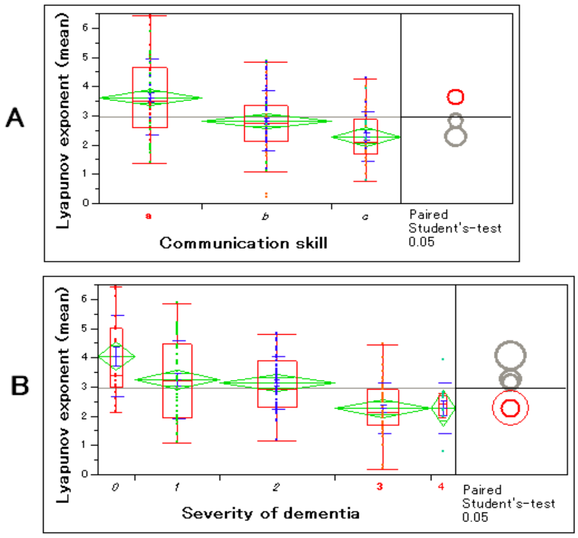

Figure. 4. Relation of the LLE and (A) communication skills and (B) severity of dementia in elderly patients.

Fifteen subjects with high cognition were selected and measurements were retaken after 9 months, in August 2004 (Figure. 5). Values of the LLE increased in some subjects and decreased in others compared to the first measurements taken in November 2003. These results indicate that changes in the LLE always occur. However, attention is needed to understand the causes of very low values.

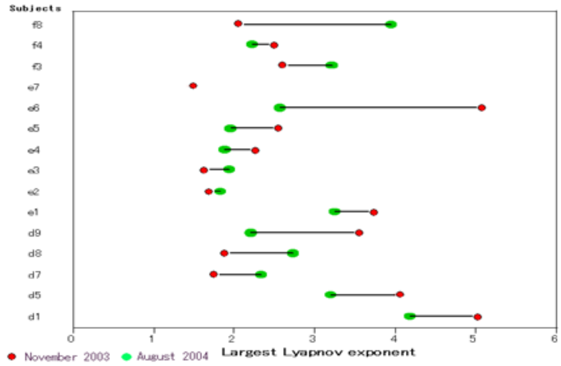

Figure 5. Results of the re-measurement of the LLE after 9 months (15 subjects). Subject e7 had died prior to the second measurement

In constellation graphs, the right side indicates small LLE and the left side indicates LLE (Figures.6,7). Because of the large quantity of data, five cases that were similar to the median of data for each rank in index (i.e., dementia, 0–4; communication skills, a–c) are shown

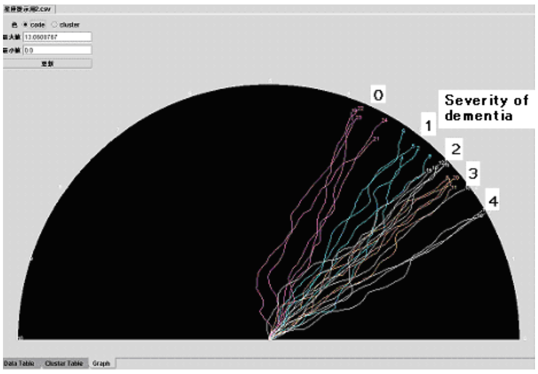

Figure 6. Relation between severity of dementia (0–4) and the LLE. One line indicates one subject

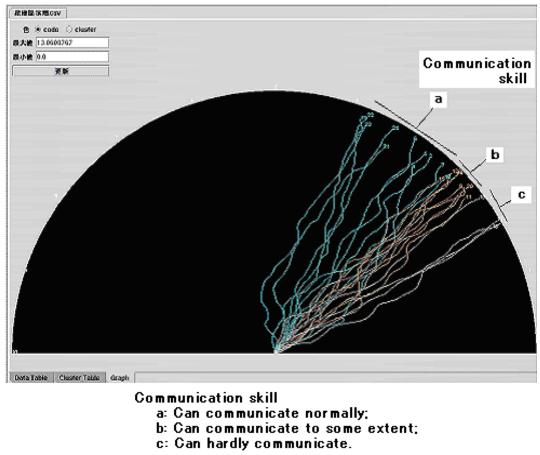

Figure 7. Relation between communication skills (a–c) and the LLE.

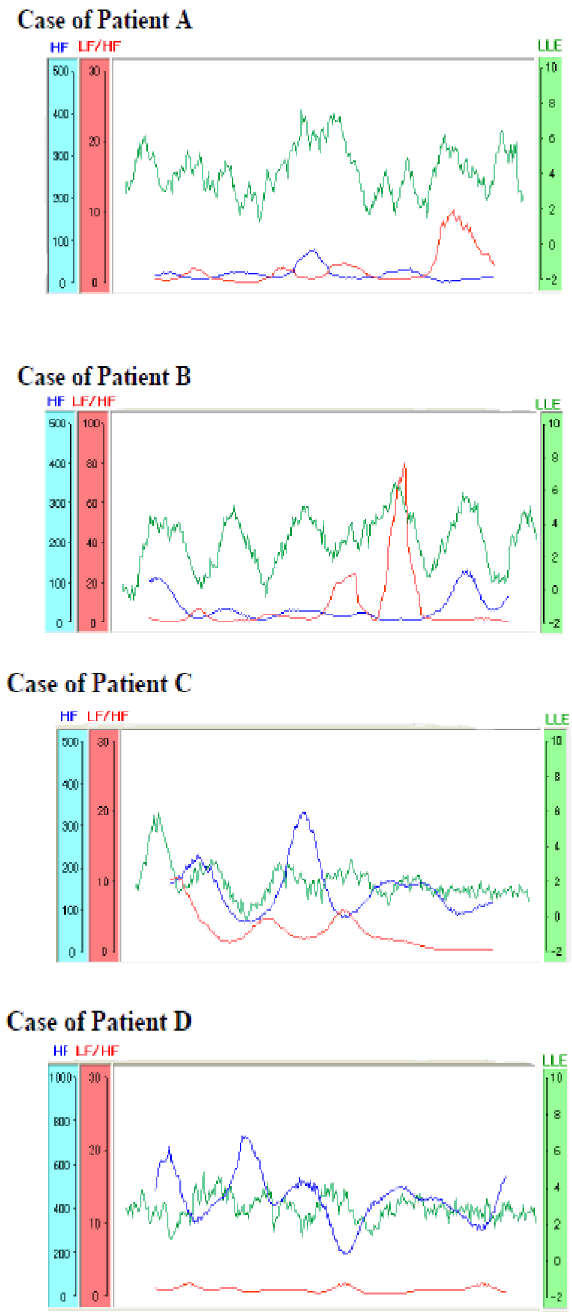

Figure 8 Relation between LLE and HF/LR of four Pacients

V. MEASUREMENT OF EFFECT OF REHABILITATION THAT USES COMMUNICATIONS

We thought that doing communications from there was a correlation in the relation between the dementia degree and the communications skill was able to increase patient with dementia's LLE. Then, the patient did the voice bet by the cooperation of the caring manager who had received the patient with dementia so far, and whether changing LLE was seen was measured.

The patient with a high dementia degree was chosen. The caring manager did communications to the patient. The caring manager who knew elderly person's state well, and knew what to be spoken to the elderly person went for years

The pulse wave device was put up to the finger first. Communications were begun after two minutes passed, and it measured it for 7-10 minutes.

The sympathetic nerve and parasympathetic were measured from the pulse wave at the same time. It has been understood that the reaction is also slow because it is sleepy when a parasympathetic value is high.

22 patients' sex, the age, level of care needed, the disease name, and communications and states of the measurement are shown. Seven people in 22 people reacted to care manager's calling. Seven people are a high values parasympathetic, and seem to be high the sleep state. An effective pulse wave for the analysis because be not able geostationary was not able to take the finger in eight people of the remainder.

Next, changing LLE, the sympathetic nerve, and parasympathetic is shown in the graph about the patient from whom the effectiveness of communication was seen. A and B are examples that were seen the communication effect. C and D are examples of the patient that show parasympathetic is high. The communication effect is not remarkable because it is sleepy.

HF indicates a parasympathetic value. LF/HF indicates the value of the sympathetic nerve.

VI. CONCLUSIONS

Patient with dementia's value of LLE tends to be continuously low. LLE decreases when the dementia advances in the communications skill in the ADL index. The decrease in the communications skill is related to the dementia.. Communications are important elements to press changing LLE. The present study measured the pulse wave of 22 patients with dementias. The experiment method examined how to change LLE when the caring manager who knew the condition of the patient talked to the patient. Eight patients were not able to measure it because of the vibration and the tremble of the finger. A big change of LLE was seen as for seven patients that were able to be measured. Seven patients saw parasympathetic and the substantial change was not seen in LLE in revitalization. It seems that this is a sleep state. Communications are important elements to press the change of the LLE.

It is thought that communications are useful for the patient's with dementia recovery or prevention.

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